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Sampling Episode Report Norwegian Star Sampling Episode 6504

Chapter 2 Wastewater System and Sampling Points

March 2006

2.0 WASTEWATER SYSTEM AND SAMPLING POINTS

This section describes graywater and sewage generation, collection, and treatment on the Star, as well as the sample collection points and flow meter locations and installation points used in this sampling episode.

The data and information gathered through this sampling episode were collected using EPA's authority under section 308 of the Clean Water Act, as also provided by Title XIV. Norwegian Cruise Lines voluntarily provided information and data gathered for and represented in this report, notwithstanding the above cited authority, in the interest of research for the improvement of wastewater treatment standards. Note that certain information has been removed from this section to protect material for which a claim of confidential business information (CBI) has been made. The confidential version of this report can be found in the confidential portion of the Cruise Ship Rulemaking Record.

2.1 Wastewater Generation and Collection

The ship's collection, holding, and transfer system (CHT) collects and transfers graywater and sewage generated onboard to the ship's Scanship treatment system or to overboard discharge. For the purpose of this report, graywater refers to non-sewage wastewaters that are collected by the CHT system. The CHT system is composed of five subsystems, referred to by the ship's crew as the galley, food pulper, accommodations, laundry, and sewage systems. Figure 2-1 is a simplified diagram of the Star's graywater and sewage CHT system. (Figure 2-1 has been redacted to prevent disclosure of material for which a claim of CBI has been made.) Wastewater sources collected by each of the five subsystems are described in Table 2-1. Potable water is used as source water for all ship operations that generate graywater and sewage (e.g., laundry, galley, food pulper, sinks, showers, and toilets). Potable water is produced onboard and seldom bunkered while in port.

2.2 Wastewater Treatment

The Star is outfitted with a Scanship treatment system, an advanced wastewater treatment system that uses aerobic biological oxidation followed by dissolved air flotation and ultraviolet (UV) disinfection. Figure 2-2 is a simplified diagram of the Scanship treatment system. (Figure 2-2 has been modified to prevent disclosure of material for which a claim of CBI has been made.)

Wastewater from the galley, accommodations, laundry, and sewage CHT subsystems combine in one graywater and sewage holding tank. (Note that food pulper wastewater is not routed to the graywater and sewage holding tank, but instead is discharged without treatment outside 12 nm from shore.) The combined wastewater is then pumped through two coarse drum filters operated in parallel (mesh size 0.5mm) and then through two aerated bioreactors operated in series. Each bioreactor contains free floating plastic beads to support biological growth. Operators add a defoaming agent to the bioreactors. Following aeration and biodegradation in the bioreactors, the wastewater is pumped to two dissolved air flotation (DAF) units operated in parallel to separate solids. Anionic polymer and flocculant (polyaluminum chloride) are added to the wastewater to aid the flotation process.

From the DAF units, the wastewater is pumped to two polishing screen filters operated in parallel (mesh size 0.03 mm). In the final stage of treatment, the wastewater undergoes UV disinfection in three parallel UV units for destruction of bacteria and viruses. The UV units are cleaned approximately every three weeks using Metalbrite solutions containing 80% water and 20% phosphoric acid. The Metalbrite solution is reused until spent.

According to the ship's crew, the Scanship treatment system can treat 1,400 m³ (370,000 gallons) per day of wastewater generated onboard. This is well in excess of its typical daily load, approximately 840 m³ (222,000 gallons), as determined based on measured flows collected during this sampling episode.

The Scanship treatment system operates continuously, regardless of the ship's location (e.g., in port, at sea within Alaska waters, at sea outside Alaska waters). The vessel typically continuously discharges treated wastewater from this system overboard. Where overboard discharge is prohibited, such as in Glacier National Park, treated wastewater is diverted to storage in double-bottom holding tanks and held for eventual discharge overboard outside 12 nautical miles (nm). Treated wastewater storage capacity totals 1,437 m³.

Treated wastewater is recycled back to the treatment system when effluent TSS concentrations exceed 27 mg/L (determined based on a correlation to measured effluent turbidity) to ensure that inadequately treated wastewater is not discharged.

The Scanship treatment system generates two types of residual waste: coarse drum filter solids and DAF solids (excess biomass from the bioreactors). These residuals are routed to the solids holding tank. Figure 2-3 is a diagram of the Star treatment residual handling system. (Figure 2-3 has been redacted to prevent disclosure of material for which a claim of CBI has been made.) The maximum wet solids generation rate is 25 m³ per day. The combined residuals are dewatered using a centrifuge followed by a press to increase the solids content to over 20%. The dewatered solids are dried further in a dryer to over 60% dryness and then incinerated onboard. Incinerator ash is disposed of on shore as a non-hazardous waste. Wastewater generated from solids dewatering is returned to the graywater and sewage holding tank at the start of the Scanship treatment system.

2.3 Wastewater and Residual Sample Collection Points

Samples were taken from the graywater sources (galley, laundry, accommodations, and food pulper); influent to the treatment system (combined graywater and sewage); influent to the UV disinfection portion of the treatment system; effluent from the treatment system; source water (water from the ship's potable water system); wastewater treatment residual; and incinerator ash. Table 2-1 describes the wastewaters sampled, their sampling point locations, their flow measurement locations (if applicable), and the number of days they were sampled. Table 2-2 provides the same information for the treatment residual and

incinerator ash sampled. In general, graywater and influent to and effluent from the treatment system samples were taken for five 24-hour periods, while samples of food pulper wastewater and wastewater treatment residual were taken for one 24-hour period. See Section 3.2 and Table 3-2 for information on the analytes tested.

Samples were collected from the ship's potable water system (source water) to determine if any of the target analytes were present as background contamination. One trip blank was prepared and analyzed for volatile organics to evaluate possible contamination during shipment and handling of samples. Finally, an equipment blank was prepared and analyzed to evaluate possible contamination caused by the sampling equipment.

Samples were not taken directly from the sewage CHT system. In addition, samples could not be collected of wastewater held in double-bottom holding tanks for discharge outside 12 nm from shore (i.e., treated effluent diverted to storage while the ship cruised Glacier Bay) because (1) double-bottom holding tanks cannot be accessed directly due to safety considerations, and (2) sampling from the holding tank discharge manifold would characterize combined holding tank discharges and not discharges specific to the holding tanks of interest.

2.4 Flow Meter Locations

Strap-on ultrasonic flow meters (Controlotron Model 1010) were installed at five sampling locations to collect flow data and to control automatic composite sample machines (by triggering collection after a defined amount of flow passed through the pipe). The first location was on the discharge line from the galley wastewater holding tank (galley wastewater, SP-1; see Table 2-1 for a description of wastewaters and Figure 2-1 for a simplified graywater and sewage CHT system diagram showing sampling points and flow meter locations). The second location was on the discharge line from one of the fourteen accommodations wastewater collection tanks (accommodations wastewater, SP-3; see Table 2-1 and Figure 2-1). The third location was laundry wastewater (SP-4; see Table 2-1 and Figure 2-1); this flow meter was installed on the discharge line from the laundry wastewater holding tank. The fourth flow meter location was at the influent to the wastewater treatment system on the inlet pipe to the two coarse drum filters

(SP-5; see Table 2-1 and Figure 2-2). The final location was at the effluent from the wastewater treatment system (on the overboard discharge line for the treated effluent, SP-7/8; see Table 2-1 and Figure 2-2).

Flow estimates for the food pulper wastewater were provided by the ship's crew.

Table 2-1

**Wastewater, Sampling Point, and Flow Meter Descriptions,
Norwegian Star**

Descriptions of wastewaters sampled, sampling point locations, flow meter locations, and number of days sampled for the Star sampling episode (August 8 through August 13, 2004). Note that certain information has been removed from this table to prevent disclosure of material for which a claim of CBI has been made.

Wastewater Name	Wastewater Description(a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Galley	Wastewater from the ship's galley.	SP-1	Sample tap was installed on the discharge line from the galley wastewater holding tank.	Strap-on flow meter was installed on the discharge line from the galley wastewater holding tank (the same discharge line as the installed sample tap).	5
Food Pulper	Wastewater from the Somat food pulper system. Food waste is mixed with water and processed into a slurry. The food slurry is then separated into semi-dry food solids and wastewater (food pulper wastewater). Food pulper wastewater is routed to a food pulper wastewater holding tank for recirculation back to the Somat system. Food pulper wastewater is disposed of at sea outside 12 nm.	SP-2	Samples were collected from a sample tap located on the food pulper wastewater holding tank.	Flow measurements not required. Approximately 10 m ³ of food pulper wastewater is generated per day, according to the ship's crew.	1 (Day 3)
Accommodations	Wastewater from sinks, tubs, and showers in guest and crew accommodations.	SP-3	Sample tap was installed on the discharge line from one of several collection tanks. According to the ship's crew, all accommodations collection tanks receive similar wastewater; therefore, the specific collection tank sampled was selected based on accessibility.	Strap-on flow meter was installed on the discharge line from one of the accommodations collection tanks (the same discharge line as the installed sample tap).	5
Laundry	Wastewater from the ship's laundry.	SP-4	Sample tap was installed on the discharge line from the laundry wastewater holding tank.	Strap-on flow meter was installed on the discharge line from the laundry wastewater holding tank (the same discharge line as the installed sample tap).	5

(a) List of wastewater sources may not be comprehensive.

(b) See Figures 2-1 and 2-2 for simplified diagrams of the Star graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.

(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

Table 2-1 (Continued)

Wastewater Name	Wastewater Description(a)	Sampling Point # (b)(c)	Sampling Point Description (b)	Flow Meter Description (b)	# of Days Sampled
Influent to Scanship Treatment System	<p>Combined wastewaters from four collection, holding, and transfer (CHT) subsystems (laundry, accommodations, galley, sewage). Does not include food pulper wastewater, which is discharged without treatment.</p> <p>A vacuum CHT system conveys sewage from passenger and crew toilets and urinals. Gamazyme is added to the toilets as a biological cleaner. Note that samples were not taken directly from the sewage CHT system.</p> <p>Sewage and graywater combine in the graywater and sewage holding tank, which is the first component of the Scanship treatment system.</p>	SP-5	Sample tap was installed on the combined wastewater inlet pipe to the treatment system (before the coarse drum filters).	Strap-on flow meter was installed on the inlet pipe to the coarse drum filters (the same discharge line as the installed sample tap).	5
Influent to UV Disinfection Part of Scanship Treatment System	Wastewater following treatment by biological oxidation, dissolved air filtration, and polishing screen filtration but prior to UV disinfection.	SP-6	Sample tap was installed on the wastewater transfer pump to the UV disinfection unit.	Flow measurements were not required.	5
Effluent from Treatment	<p>Final treated wastewater effluent from the Scanship wastewater treatment system.</p> <p>Effluent is typically continuously discharged overboard. Where discharge is prohibited (e.g., Glacier Bay), wastewater is diverted to storage in double-bottom holding tanks for overboard discharge outside 12 nm from shore.</p>	SP-7/8	Sample tap was installed on the overboard discharge pipe following UV disinfection.	Strap-on flow meter was installed on the overboard discharge pipe following UV disinfection (the same discharge line as the installed sample tap).	5
Source Water	Potable water used as source water for all systems that generate wastewater that is treated by the Scanship treatment system.	SP-11	Samples collected from the bathroom sink in a sampling team member's cabin.	Flow measurements were not required.	1 (Day 4)

(a) List of wastewater sources may not be comprehensive.

(b) See Figures 2-1 and 2-2 for simplified diagrams of the Star graywater and sewage CHT and treatment systems indicating the sampling point and flow meter locations.

(c) Two sampling point numbers indicate duplicate samples taken at this point for certain analytes. See Section 5.2.3 and Tables 5-4 and 5-5 for details on duplicate sampling.

Table 2-2

**Treatment Residual and Incinerator Ash Descriptions,
Norwegian Star**

Descriptions of treatment residuals and incinerator ash sampled, sampling point locations, flow meter locations, and number of days sampled for the Star sampling episode (August 8 through August 13, 2004). Note that certain information has been removed from this table to prevent disclosure of material for which a claim of CBI has been made.

Treatment Residual Name	Treatment Residual Description	Sampling Point # (a)	Sampling Point Description (a)	Flow Meter Description	# of Days Sampled
Dried Wastewater Treatment Sludge	Combined Scanship treatment residuals (coarse drum filter solids and dissolved air flotation solids) that are dewatered and dried.	SP-9	Sample was collected from the dried sludge screw feeder to the incinerator.	Flow measurements not required. Approximately 25 m ³ of wet treatment sludge are generated per day according to the ship's crew.	1 (Day 1)
Incinerator Ash	Ash generated from the incineration of trash (e.g., cardboard, paper, plastic) and dried wastewater treatment sludge. Incinerator ash is collected in incinerator ash storage hoppers for disposal onshore.	SP-10	Samples were collected directly from an incinerator ash storage hopper.	Flow measurements not required.	2 (Day 1 and Day 4)

(a) See Figure 2-3 for simplified diagram of the Star's wastewater treatment residual handling system indicating the sampling point locations.

Figure 2-1 has been redacted to prevent disclosure of material for which a claim of confidential business information has been made.

**Figure 2-1. Graywater and Sewage Collection, Holding and Transfer System,
Norwegian Star**

Simplified diagram of the Norwegian Star graywater and sewage CHT system. See Table 2-1 for a list of wastewater streams in each wastewater source.

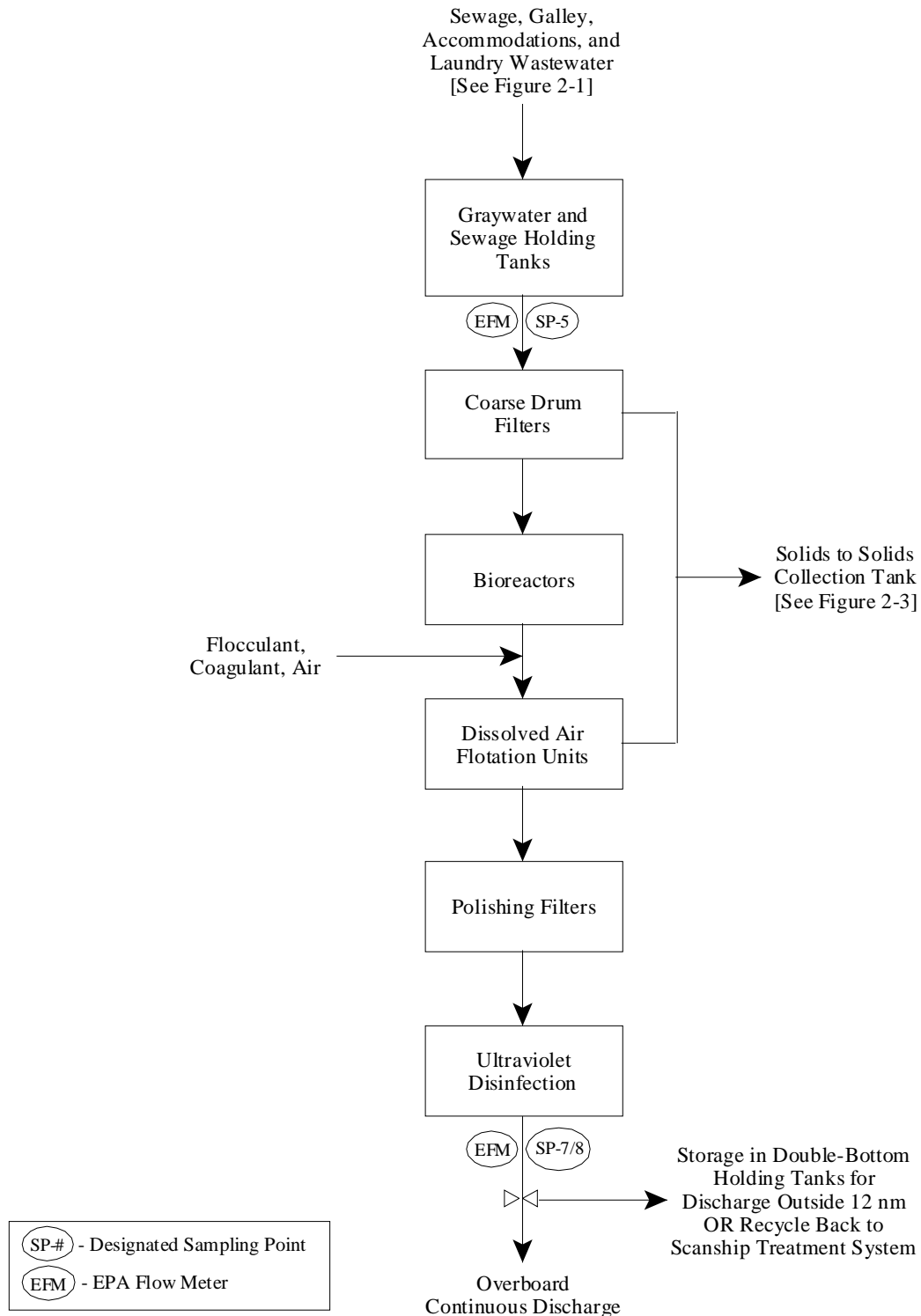


Figure 2-2. Scanship Treatment System, Norwegian Star

Simplified diagram of the Norwegian Star Scanship treatment system. See Table 2-1 for a list of wastewater streams in each wastewater source, and Figure 2-1 for their collection and conveyance to the treatment system. Note that Figure 2-2 has been modified to prevent disclosure of material for which a claim of CBI has been made.

Figure 2-3 has been redacted to prevent disclosure of material for which a claim of confidential business information has been made.

Figure 2-3. Sewage/Graywater Treatment Residual Handling, Norwegian Star

Simplified diagram of the Norwegian Star sewage/graywater treatment residual handling system. See Table 2-2 for descriptions for the treatment residuals and Figure 2-2 for their points of generation by the Scanship treatment system.